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DESIGN AND TEST OF A MOBILE MISSION CONTROL STATION FOR USE IN --ETC(U)

APR 78 W F GRIEDER, D J MESSURI, T P WHEELER F19628-76-C-0198

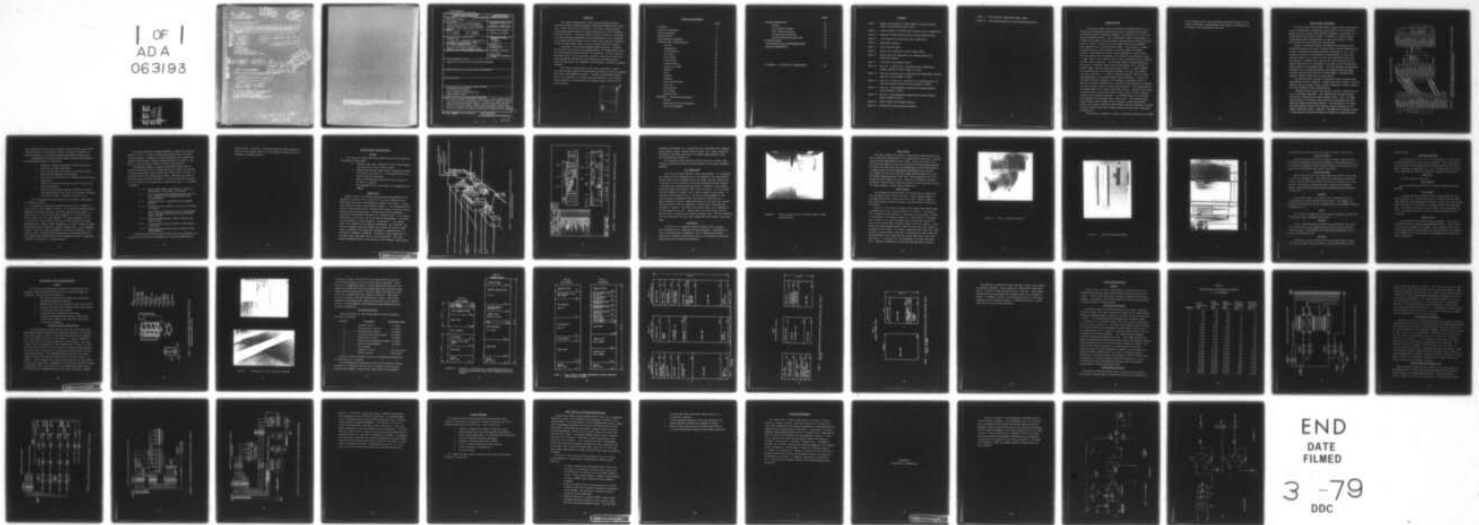
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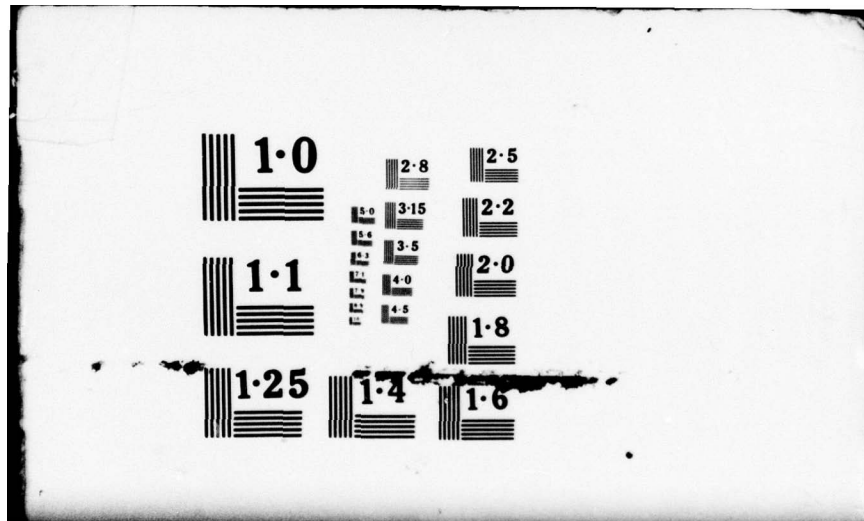
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DESIGN AND TEST OF A MOBILE MISSION CONTROL STATION FOR
USE IN BALLOONBORNE INFRARED RESEARCH EXPERIMENTS
(BAMM PROJECT).

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PREFACE

The Balloon Altitude Mosaic Measurements (BAMM) Program, sponsored by Space and Missile Systems Organization (SAMSO/AFSC) under P.E. 63424F, Project 2123, Task 04, is an infrared earth background measurements experiment that is being conducted by Air Force Geophysics Laboratory (AFGL). The Optical Physics Division of AFGL is responsible for overall technical management of the program; however, the complexity of the experiment has dictated a need to draw on the support and expertise of other divisions within AFGL, as well as outside contractual support.

To provide a coordinated and highly visible method for systematic documentation of all facets of the BAMM program, the BAMM Report series has been established within the AFGL-TR framework. The first report in the BAMM series, now in preparation, presents a general overview of the entire experiment, with this and succeeding reports providing detailed system specifications and capabilities, and the results of the data acquisition missions.

This report presents details of the design, fabrication, and test of a trailer facility equipped with appropriate electronics to exercise command and control of the BAMM field efforts. Included in this Mission Control system are capabilities to command instrument functions on the payload, evaluate telemetered data and produce permanent copies of both raw and processed data.

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Figure 17 FM radiometer output data display system.

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INTRODUCTION

The Balloon Altitude Mosaic Measurement (BAMM) program is an infrared earth background measurement program sponsored by the Space and Missile Systems Organization (SAMSO) and directed by Air Force Geophysics Laboratory (AFGL). The experimental concept of the program is to obtain high altitude (~ 100 kft) infrared measurements of earth (and cloud) features in order to characterize their spatial and temporal signatures both spectrally and in selected infrared bands. These data are intended to provide inputs to future designs of military satellite surveillance systems, consequently the need for "above atmosphere" measurements. The data requirements necessitate measurement of earth features in both a "stare" and a "scan" mode as well as with multi detector arrays (mosaic) to obtain spatial resolution. The principle infrared measurement instruments are a 16 detector (InSb) mosaic interferometer and a coaligned 16 detector (PbS) radiometer both cryogenically cooled. A balloon platform was selected because of its altitude capability (~ 100 kft), low velocity (< 30 kts), endurance (5 - 10 hours), payload capacity (~ 3500 lbs), stable flight performance and reliable payload recovery potential. In order to accomplish the stare objectives of the program, the payload system includes an inertially stabilized servo controlled pointing platform commanded from the ground to acquire and track ground targets. The sophistication of the BAMM payload and mission created the need for a ground control system to exercise both command and control of the mission as well as hands-on control of the experiment operation. The BAMM Mission Control trailer was designed to accommodate these requirements. The specific purpose of the Mission Control system was to "provide a mobile instrumented facility from which to direct the BAMM experiment field programs, including real time control of the balloon flight missions and quick look assessment of flight data".

This report is intended to provide a reference document for the BAMM

Mission Control trailer system including concepts and specifics of the design and equipment configurations so that changes or maintenance of the system can be implemented with ease.

BASIC DESIGN CONCEPTS

The basic design of the BAMM Mission Control system was dictated by the instrumentation configuration on the payload and the availability of certain Air Force ground instrumentation in existence, specifically the AFGL telemetry and tracker systems. In addition, a primary mission consideration was the fact that hands-on control was essential to affect the acquisition of ground targets for measurement.

Figure 1 schematically depicts the BAMM instrumentation system including the payload, the AFGL telemetry/tracker and the BAMM Mission Control. Data and housekeeping information (temperatures, etc.) from the payload sensors are transmitted by S-band telemetry to the ground receiving station on four links; two pulse code modulation (PCM) links, one frequency modulation (FM) link, and one wide band television link. Uplink command data are transmitted to the payload from the ground telemetry station on two independent links. One link commands all experiment functions such as pointing the platform and changing instrument gains. The other command link controls the balloon flight by operating ballast systems, balloon valving, and recovery systems.

The ground telemetry/tracker combination provides the experiment with telemetry receiver capability, magnetic tape data recording, some preliminary PCM processing, uplink command transmitters, balloon tracking data, and standard UT time code generation.

A Mission Control facility was required to provide command and control of the BAMM experiment. This important and necessary function could not be provided by any other available facility. Thus, the design and fabrication of a Mission Control facility was formulated as a task under the BAMM measurement program. The facility had to be mobile and self-contained because of the different mission locations for the balloon experiments (Chico, Holloman, and Eglin) and the BAMM concept of exercising the telemetry/tracking and command and control functions

BAMM SYSTEMS INTERFACE

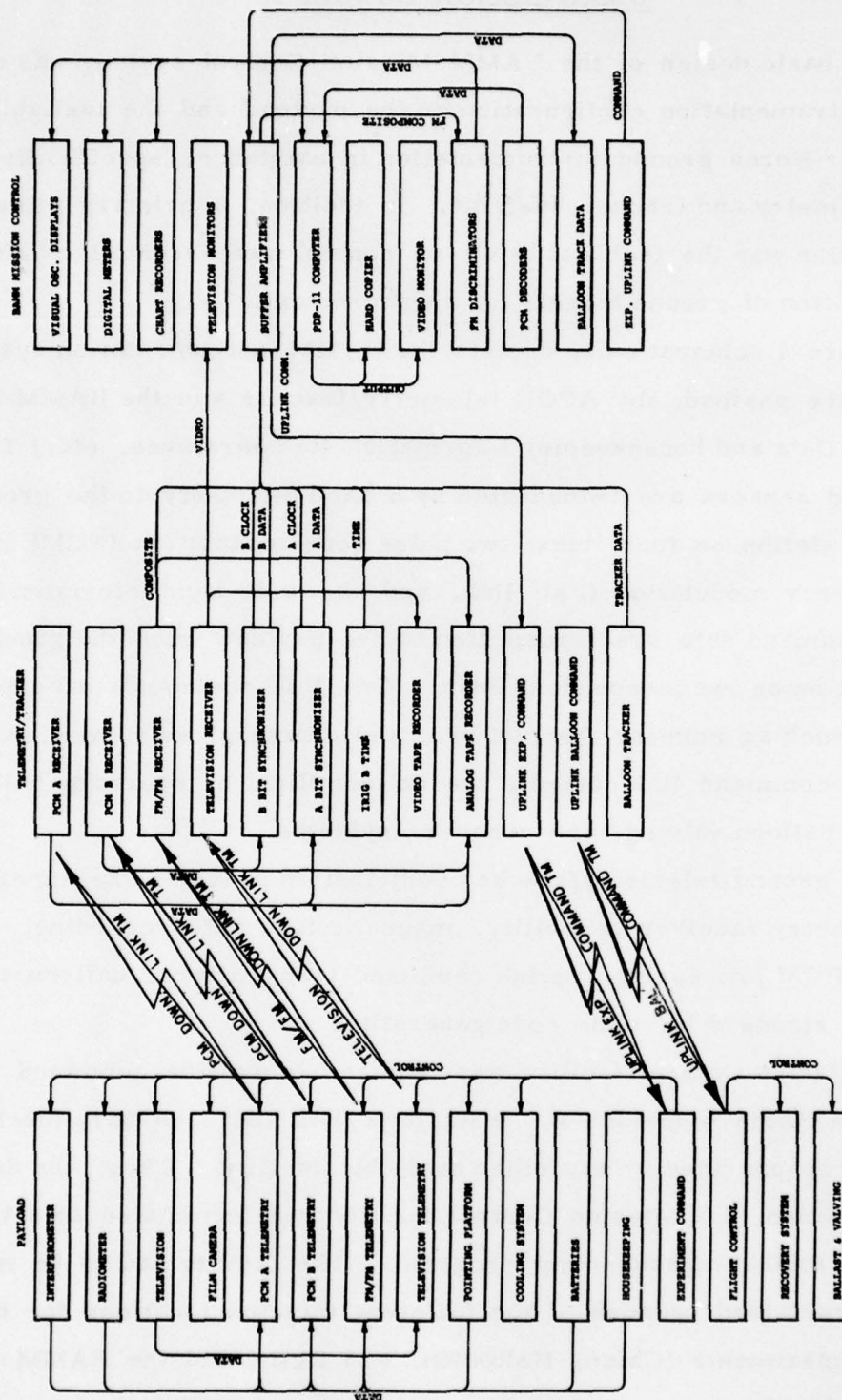


FIGURE 1 BAMM SYSTEM INTERFACE BETWEEN PAYLOAD, TELEMETRY/TRACKER FACILITY, AND MISSION CONTROL TRAILER

from downwind (sometimes remote) stations from the balloon launch sites. Downwind stations are desirable to improve tracking and telemetry reception capabilities by reducing the maximum operating telemetry range.

Requirements for specific Mission Control systems stemming from the BAMB Mission Control concept were:

1. Continuous real time monitoring of interferometer and radiometer systems performance.
2. Near real time data assessment and evaluation of interferometer and radiometer measurements.
3. Near real time monitoring of 90 channels of payload house-keeping data.
4. Continuous television monitoring of scenes viewed by the payload instruments.
5. Hands-on control (uplink command capability) of the payload pointing platform and critical instrumentation functions such as gain controls, calibration sequences, etc.

The instrumentation systems selected to satisfy these requirements are indicated in Figure 1.

In operation incoming data to Mission Control, where possible, is isolated with a buffer amplifier interface. This technique provides impedance matching, ground loop protection, and allows adjusting output signals to nominal levels. DC to 250 KHz analog amplifiers are used for FM composite and slow time code data buffering. AC coupled amplifiers (30 Hz to 30 KHz) are used for IRIG B time code (1 KHz modulated) and audio signal buffering. Optical isolation amplifiers are used to isolate and shape the incoming PCM as well as the outgoing command data. Circuit diagrams of these circuits are shown in Appendix A - Electrical Schematics. The television video is buffered with a high frequency transformer located in the overhead rack. Outputs from the buffer amplifiers are fed to appropriate decoding, discriminators, or display systems.

After discrimination, decoding and digital to analog processing the signals are fed to a variety of oscilloscopes, digital meters, and chart recorder displays. In addition, the PCM signals and some selected FM signals are fed through a specially designed interface to a PDP-11 computer for data processing, display, and hard copy production

Through these displays, computer analysis and uplink command systems, the Field Director in Mission Control can monitor and evaluate instrument performance, and command and control in near real time, all pertinent aspects of the BAMB measurements. Operation and control of the BAMB experiment after the balloon is at float altitude and all systems have been checked out is envisioned to proceed from time $T = -10$ minutes as follows:

- $T = -10$ Select ground target to be measured. Commence interferometer calibrations - record data.
- $T = -7$ Forecast and plot forecast balloon position for $T = 0$ min. Compute and set pointing platform uplink command system.
- $T = -5$ Stop interferometer calibrations and set pointing platform.
- $T = -4$ Position filter and commence radiometer calibration - record data.
- $T = -2$ Stop radiometer calibrations and set interferometer gains. Reconfirm pointing parameters and update uplink command.
- $T = -1$ Check housekeeping data, monitor television and acquire target.
- $T = 0$ Activate stare mode and commence measurements - record data.
- $T = +3$ Stop measurements and recalibrate radiometer and interferometer.

A Government owned forty (40) foot long semi-trailer (Kentucky) was selected for conversion and modification to accept the BAMB Mission

Control system. The trailer concept provided the mobile capability required and was equipped with an air ride suspension system and an air conditioner of adequate capacity.

TRAILER BODY MODIFICATION

General

The design and modification of the BAMB trailer body was based on the following considerations.

1. Existing trailer body configuration such as door locations and step-up area in the forward section.
2. Mission Control requirements such as visibility of certain instruments, map board, etc., and proximity of key personnel involved in operations.
3. Special instrumentation requirements such as those for the PDP-11 computer.
4. Environmental factors such as heat, air conditioning, and lighting.

Configuration

Figure 2 shows the originally designed trailer instrumentation configuration in isometric view - except for a few minor differences this figure depicts the major instrumentation locations in the trailer. A more precise layout is shown in the drawing of Figure 3. The configuration provides the field director and his staff with good visibility of mission control displays and the navigation map. With this basic design established, a subcontract was awarded to Fruehauf, Inc., Waltham, Mass. to accomplish modification of the trailer body to accept the instrumentation. This effort was accomplished in three (3) phases. During Phase I, the existing trailer was stripped of all existing instrumentation, wall partitions, and exterior extraneous units and prepared for internal and external modification. In addition, all running gear including air suspension were refurbished to roadworthy conditions. In Phase II, major modification to the trailer body, both inside and out, was accomplished. This work included installing floors, a false ceiling, power, windows, anchor plates,

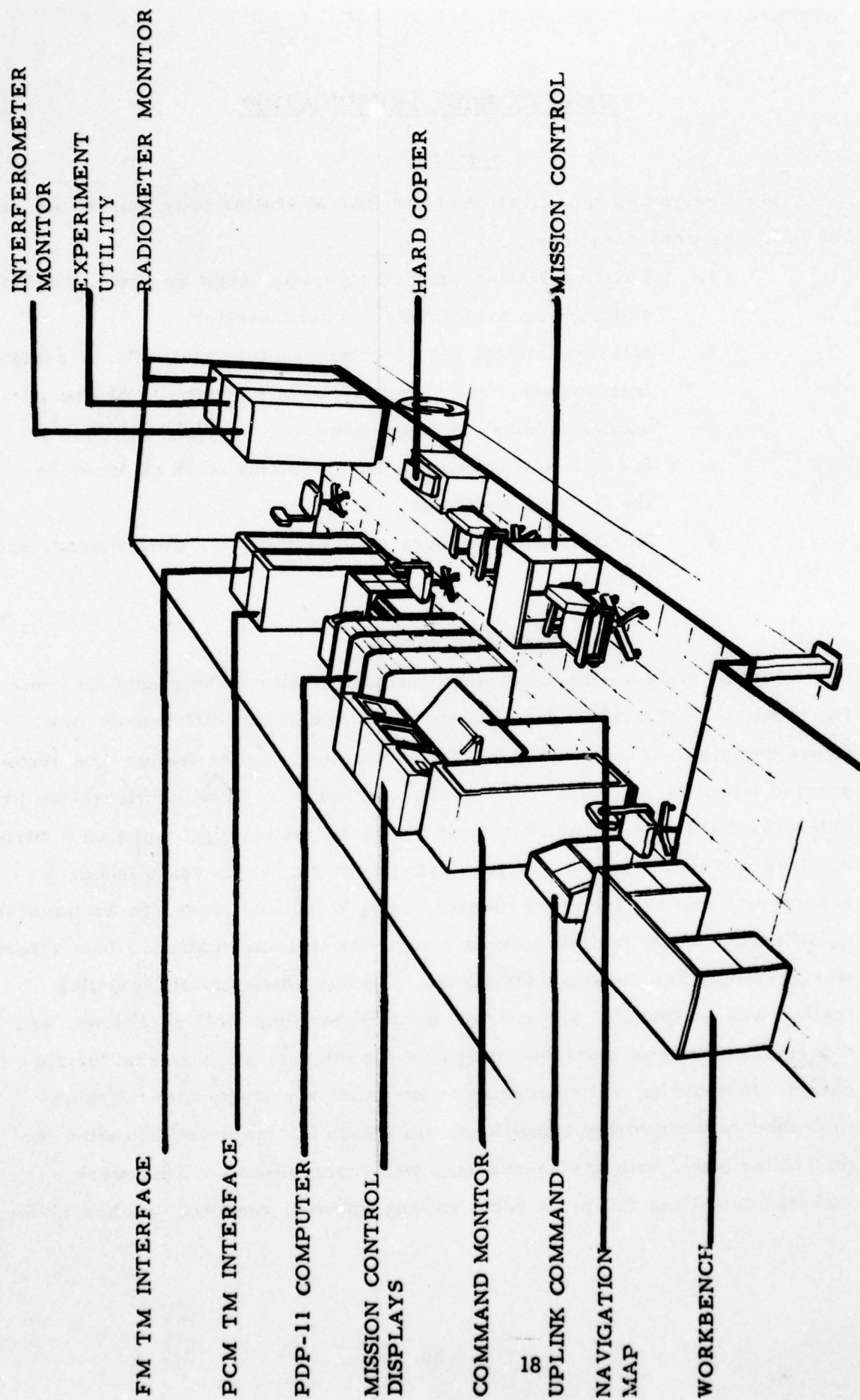


FIGURE 2 ARTIST CONCEPTION OF Bamm MISSION CONTROL TRAILER CONFIGURATION

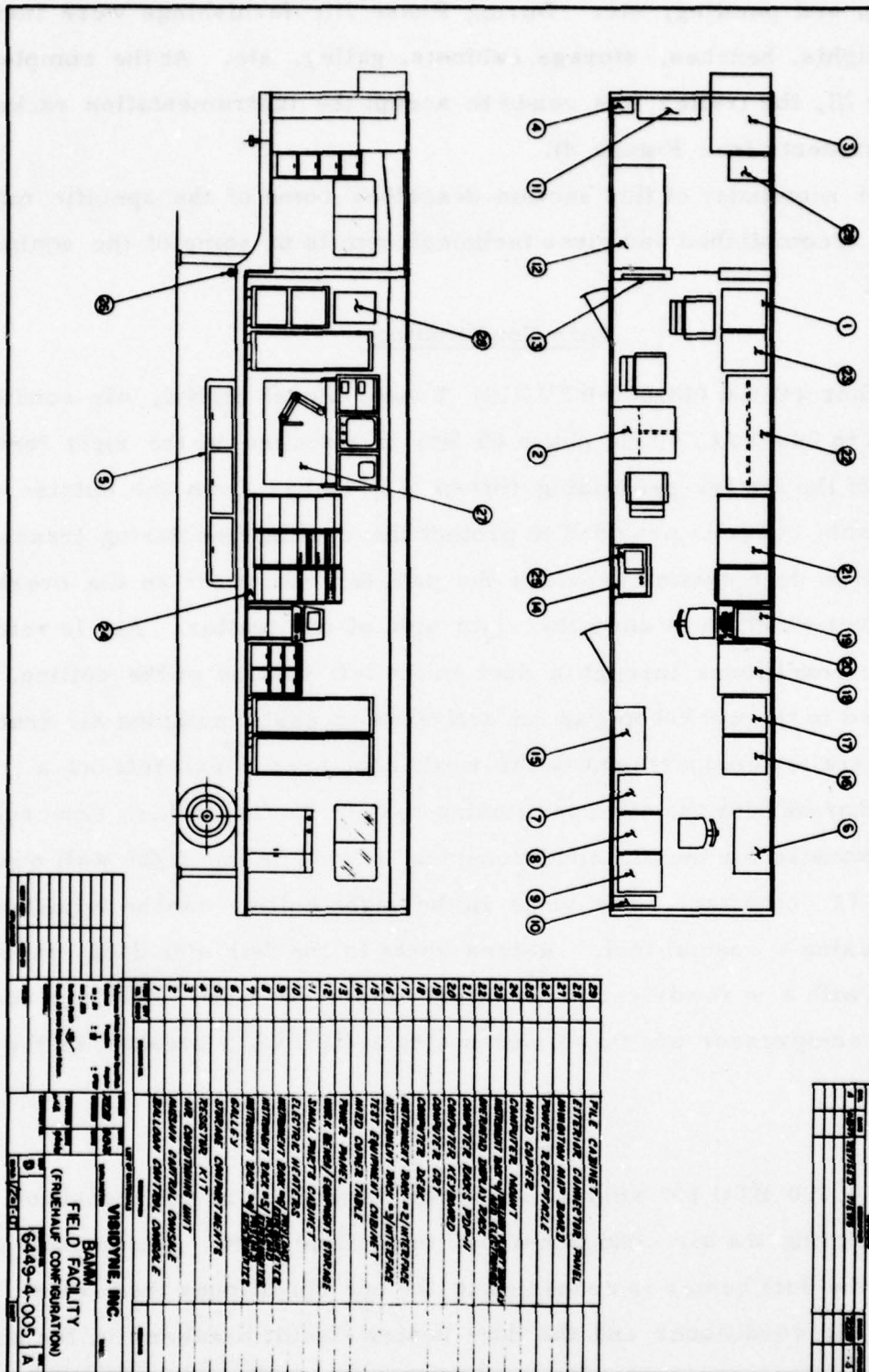


FIGURE 3 DRAWING OF Bamm MISSION CONTROL INSTRUMENTATION LAYOUT

panelling, and painting, etc. During Phase III, furnishings were installed, such as lights, benches, storage cabinets, galley, etc. At the completion of Phase III, the trailer was ready to accept the instrumentation racks and instruments (see Figure 4).

The remainder of this section describes some of the specific modifications accomplished and gives technical details of some of the equipment installed.

Air Conditioning

A four (4) ton (48,000 BTU/HR) Trane, Model SH40K, air conditioning unit (208 to 240 VAC single phase 60 Hz) is installed in the right forward portion of the trailer protruding fifteen (15) inches from the outside wall. A removable cover is provided to protect the cooling fins during transport. A transition duct system provides the path for cooled air to the overhead ceiling duct which runs down the right side of the trailer. Air is returned to the air conditioner through a duct in the left portion of the ceiling. A fan located in the workshop can be activated to assist pumping air from the main trailer compartment to the work shop area which acts as a plenum chamber for the air conditioning system (a free return type system). The thermostat for the air conditioner is located on the right wall near the PDP-11 computer. The vents in the right ceiling can be adjusted for air flow using a special tool. Return vents in the left side duct can be adjusted with a screwdriver for nominal return air flow. The air conditioner, fan, and compressor are fused with a single (208 VAC) breaker in the power panel.

Duct Heater

A 10,000 BTU (45 amps) duct heater is located in the transition duct connecting the air conditioner and the ceiling duct. Thermostat control for the duct heater is connected to the air conditioner thermostat. Both the air conditioner and the duct heater circuit breakers in the power panel must be on to operate the duct heater.

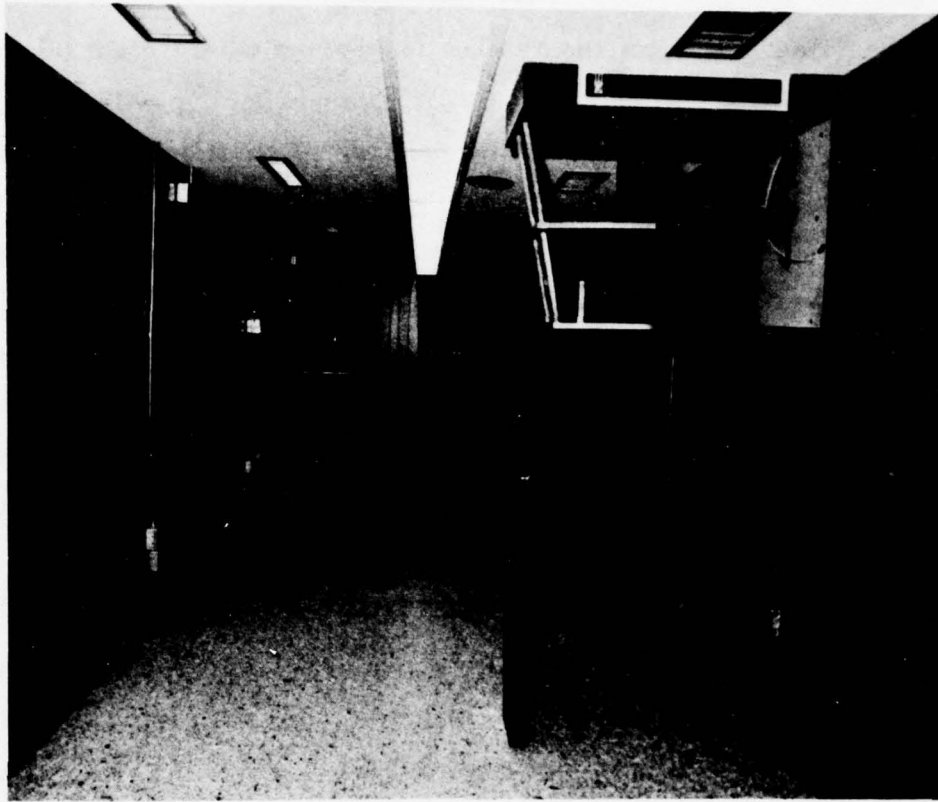


FIGURE 4 VIEW LOOKING AFT OF TRAILER BODY AFTER
MODIFICATION

False Ceiling

The false ceiling in the trailer is approximately eight (8) inches deep and is constructed with half inch (1/2") plywood held up with steel Z brackets. There are five compartments in the ceiling. One for the cold air feed and one for the warm air return as described in the preceding paragraphs. The center duct houses the fluorescent light fixtures and ceiling speakers. In addition, there are two compartments approximately six (6) inches wide adjacent to each trailer wall and running the full length of the trailer. Inside these compartments are square steel cable troughs which provide a housing for trailer power line runs. These are accessible by removing appropriate sections of the ceiling panels (held in place with wood screws). The entire ceiling is covered with acoustical tile.

Power System

The BAMM trailer power system is a four (4) wire (Y connection) three (3) phase 208/115 VAC, 60 Hz type. Total maximum capacity is 100 amps per leg with a balanced load (34.5 KW). Power is input to the trailer through an external connector located under the forward door. See Figure 5.

Power is fed to a three (3) phase circuit breaker panel (power panel) containing forty-six (46) breaker positions, see Figure 6. The panel is wired starting at the top (position 1) with Phase A, next position is Phase B, then Phase C, then Phase A again, etc. Each major 115 VAC instrument system, such as each instrument rack, is fused with separate 30 amp circuit breakers while all utility outlets are 20 amp capacity. Power cables are routed through flexible conduit up to the duct in the ceiling on the left side of the trailer. For power receptacles on the right side, cables (in pipe) are routed down to the floor, across the floor, and up the mid-section partition to the ceiling cable duct on the right side of the trailer, see Figure 7. All 30 amp 115 VAC receptacles are Hubble type twist lock. External receptacles are located near the input power connector,

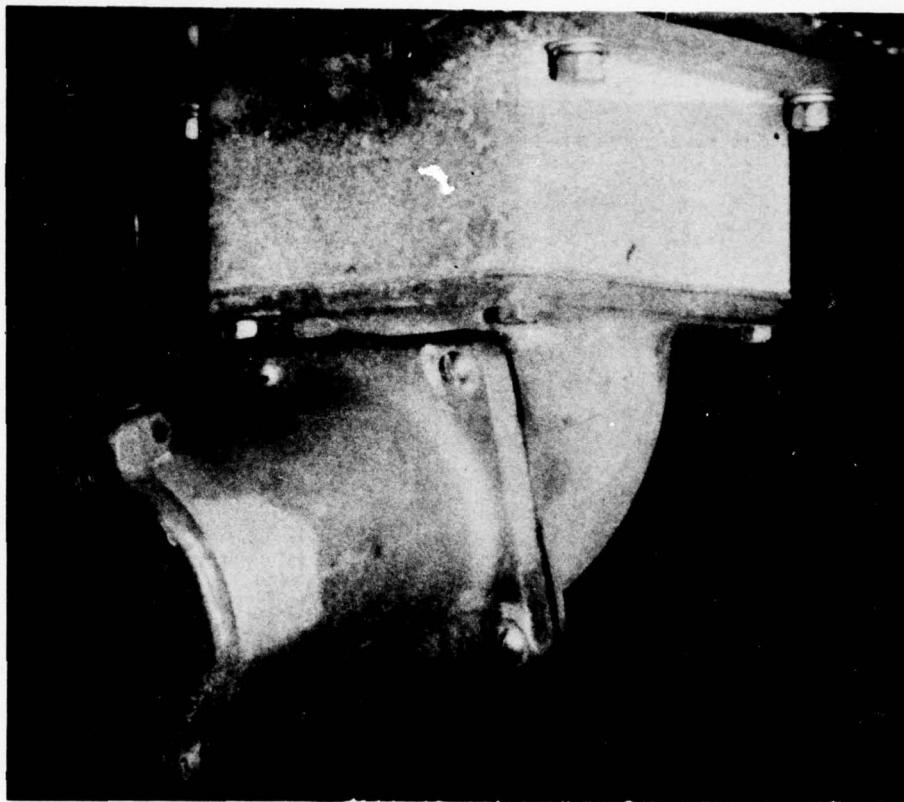


FIGURE 5 INPUT POWER CONNECTOR

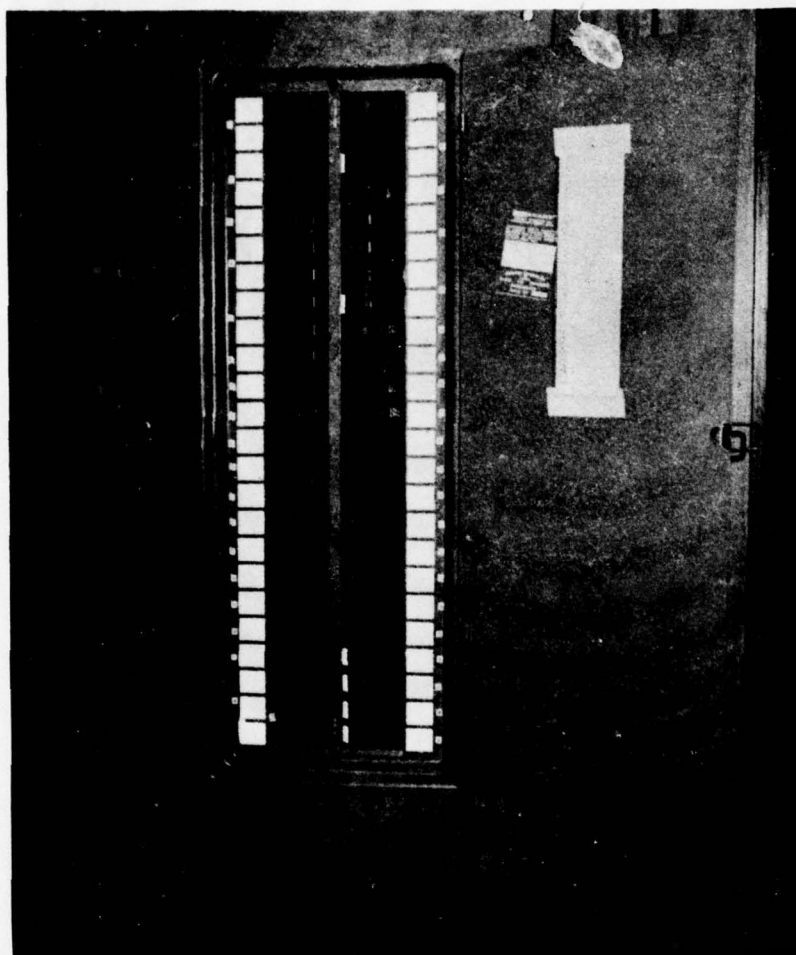


FIGURE 6 CIRCUIT BREAKER PANEL

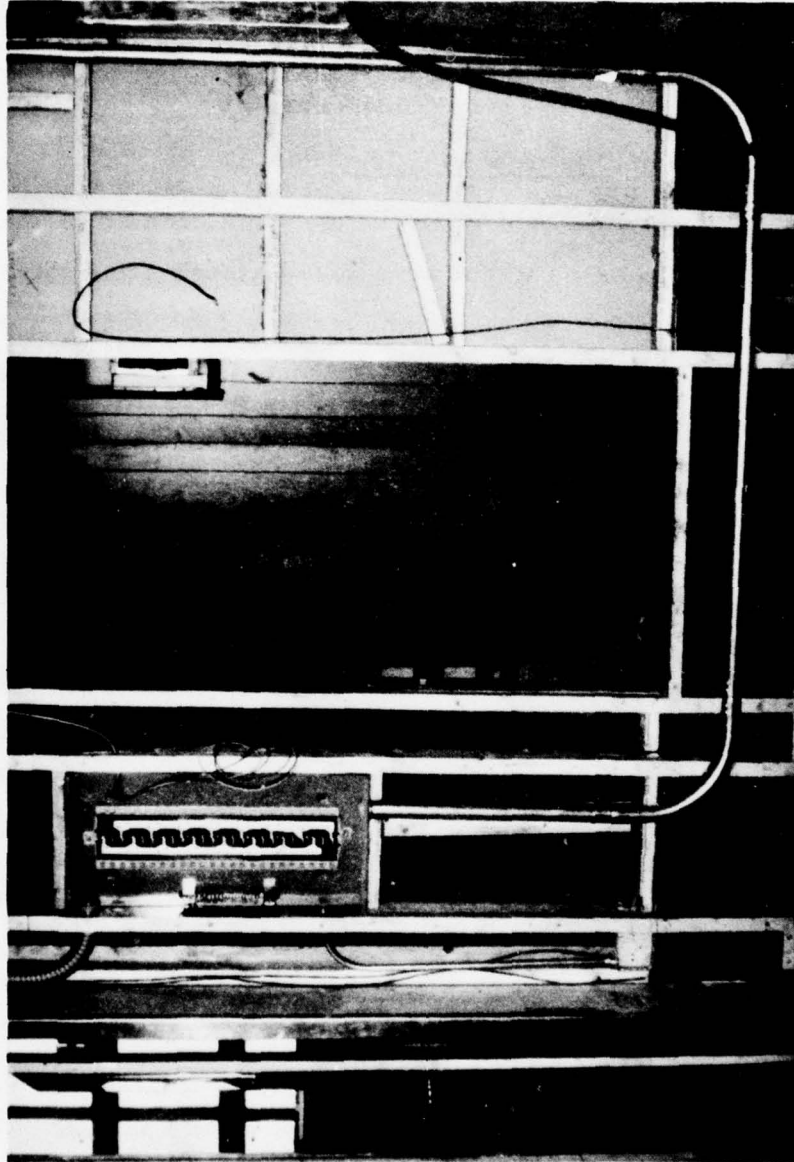


FIGURE 7 POWER CABLE ROUTING FROM CIRCUIT BREAKER PANEL

top forward left corner of trailer and aft left top corner of the trailer.

Auxiliary Heaters

Four (4) auxiliary FASCO 208 VAC electric heaters with individual thermostats and blowers are located as follows: in the workshop under the air conditioner, above the Mission Control console, in the back of the hard copier table and in the left rear corner of the trailer.

Fluorescent Lights

Eight (8) two tube fluorescent light fixtures are located in the ceiling in end on end configuration. The forward four fixtures are controlled by a switch near the front door and the rear four are controlled by a switch near the middle door. A single tube lamp is located in the workshop. Another single tube lamp is located under the overhead rack to illuminate the map board.

Speakers

Two (2) audio speakers are located in the ceiling and one (1) in the workshop area in the front wall of the partition. The speakers are separately wired and terminate at a terminal strip in the overhead command console (Rack #9).

Tires

The trailer is equipped with four (4) special airplane type radial tires which provide better tracking at high speeds.

Windows

Three (3) thermopane glass windows are incorporated in the trailer. Metal external stone covers swing down over these to prevent breakage during transport. The windows in the doors are plexiglas and do not require this kind of protection.

Insulation

All walls and ceilings in the trailer are insulated (about 2 inches). The floor has a three (3) inch insulation covered on the underside with

aluminum plate.

Rack Mounting Plates

Two (2) steel plates (1/2" x 6") are located under the floor tile and run the full length of the trailer on the right side. These anchor plates are positioned so that the instrument rack shock mounts can be bolted to them. The plates are tapped for 3/8" bolts. Similar plates are located on the right wall for side shock mounting of equipment, see Figure 9.

Floor Tile

The floor covering is vinyl tile.

Wall Panelling

Wall covering is interlocked (2 foot sections) woodgrained Marlite panelling.

Water Supply

A 30 gallon stainless steel water tank is located inside the underslung compartment. The tank filler pipe is accessible from the single right side door of the underslung compartment. An electric pump provides the needed pressure for the system to supply the galley sink (cold water only). The pump is fused with a circuit breaker in the power panel but is also controlled by an electric switch near the floor behind the navigation map.

Burglar Alarm

A microphonic burglar alarm system is installed. One sensor is located on the ceiling above the uplink command system. Another sensor is located on the ceiling over the galley. These sensors can be tied to an arming key switch on the external connector panel and can be wired to activate lights and/or a siren located in a weatherproof box outside under the air conditioner.

INSTRUMENT RACK CONFIGURATION

General

The selection of and installation method for instrumentation racks (cabinets) in the BAMB Mission Control was an important design consideration. Primary factors involved were:

1. The trailer was mobile, thus sturdy rack construction and shock mounting was necessary.
2. Standard sized (19 inch) electronic chassis were desired.
3. Access to the backs of the installed chassis was desired.
4. RFI filtering of power was desired.
5. Cooling electronic equipment was necessary.
6. Versatility and flexibility was desired so that modifications and/or changes to the electronic systems could be readily accomplished.

Instrument Racks and Installation

The instrumentation racks selected are the heavy duty 4100 series Modu-Mount Cabinets manufactured by MarkHon Industries, see Figure 8. The cabinet design is similar to racks previously produced by Honeywell and accept standard nineteen (19) inch chassis. A special modification was made to the racks to permit installation of shock mounts. The modification consists of installing two steel channels on the bottom of the rack. Four (4) Barry UC-4200-T10 shock mounts are installed on these channels and screwed (four 3/8 bolts for each mount) into tapped holes in the floor mounted anchor plates. Two additional shock mounts secure the upper portion of the racks to the wall anchor plates in a similar manner, see Figure 9. Where possible, the racks are positioned side by side in pairs so that access to the backs of equipment can be achieved simply by removing a side panel. Power strips (115 VAC) are mounted on the back panel of each rack and are equipped with Power Line filters, style 30K6, capable

FRAME
 MARKHON 4100 SERIES
 LEFT SIDE PANEL
 LK PLAIN PANEL
 RIGHT SIDE PANEL
 RK PLAIN PANEL
 BOTTOM PANEL
 PG PLAIN
 FRAME BASE
 CA NO CASTERS
 TOP PANEL
 TV VENTED
 REAR PANEL
 AK PLAIN
 HEIGHT OPENING
 63" AND 56"
 WIDTH OPENING
 19"
 DEPTH OPENING
 30"

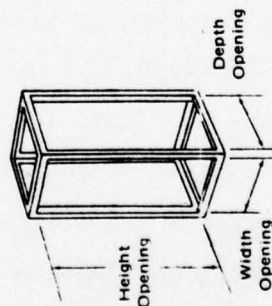
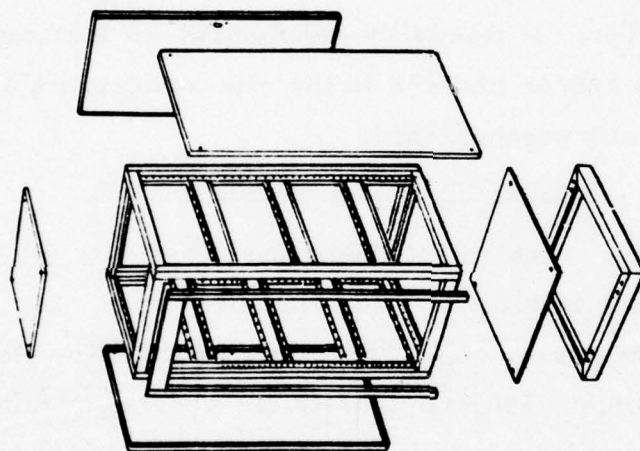


FIGURE 8 CONSTRUCTION AND NOMENCLATURE FOR MARKHON 4100 SERIES
 INSTRUMENTATION CABINETS (RACKS)

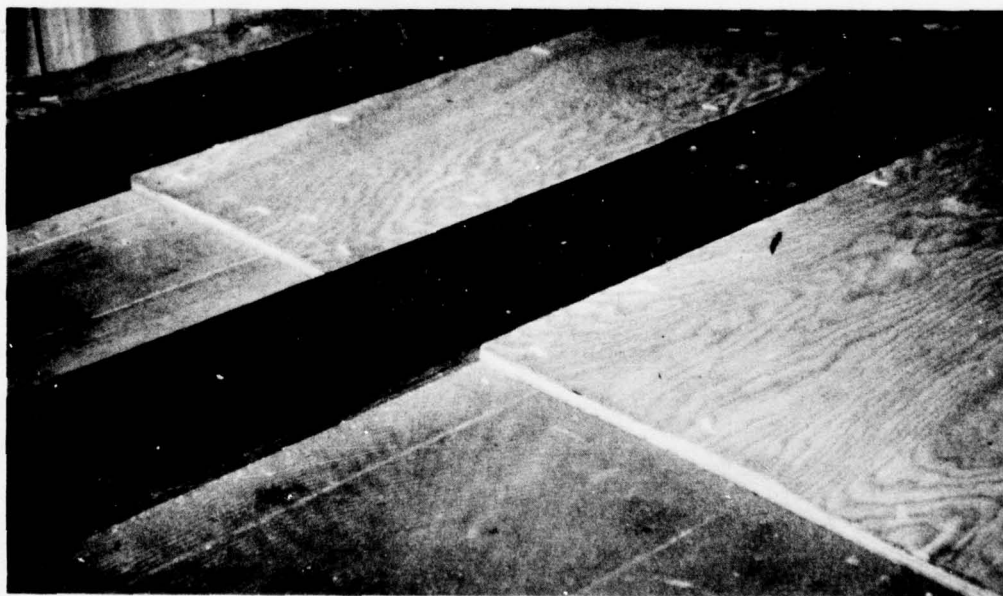
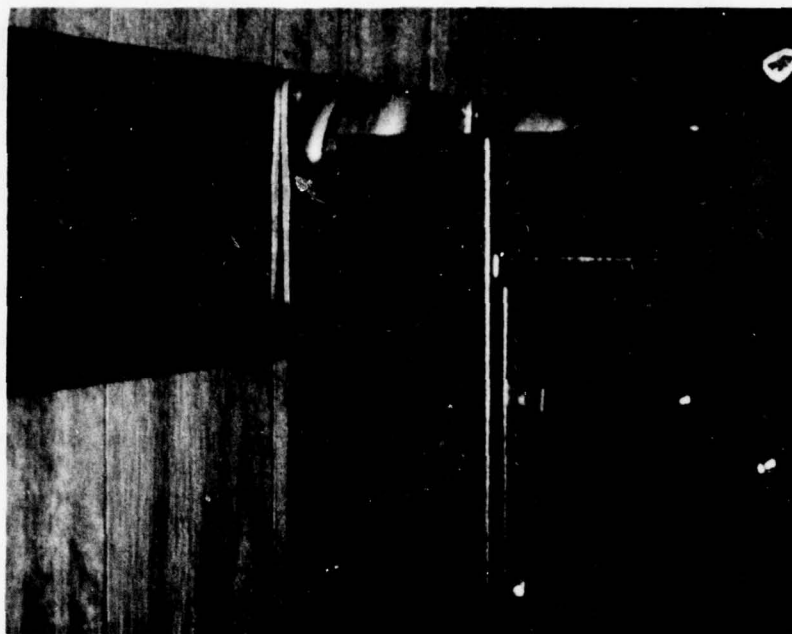


FIGURE 9 INSTRUMENT RACK MOUNTING SCHEME

of handling 30 amps. Each rack is also equipped with two speed BUD B-25A blowers capable of 180 cfm and 360 cfm air movement. These blowers are equipped with filters. A BNC panel at the top of each rack containing insulated BNC coax feed-through connectors provide the signal cabling interface into the racks. Interrack signal connections are made using coax cable (RG 188A) with crimp-on connectors. These cables are routed in plastic cable ducts attached to the ceiling. This cabling technique and instrument rack configuration provides great versatility because it permits complete instrumentation changes without disrupting permanent installations.

Rack Instrumentation

Referring to Figure 2, the instrumentation racks are numbered and defined as follows:

<u>Rack No.</u>	<u>Description</u>	<u>Usable Rack Space</u>
1	Command monitor	63 inches
2	PCM telemetry interface	63 inches
3	FM telemetry interface	63 inches
4	Radiometer experiment monitor	56 inches
5	Experimenter Utility	56 inches
6	Interferometer Experiment Monitor	56 inches
7	Mission control displays	63 inches
8	Not installed	--
9	Command console	24.5 (each side)
10	Uplink command	38.5 inches

Rack No. 8 was not installed but room is available aft of Rack No. 3 if an additional rack is required.

The instrumentation arrangement in these racks is shown in Figures 10 through 14. The figures show the chassis installed in the racks and also the chassis height in inches (lower right corner of each chassis).

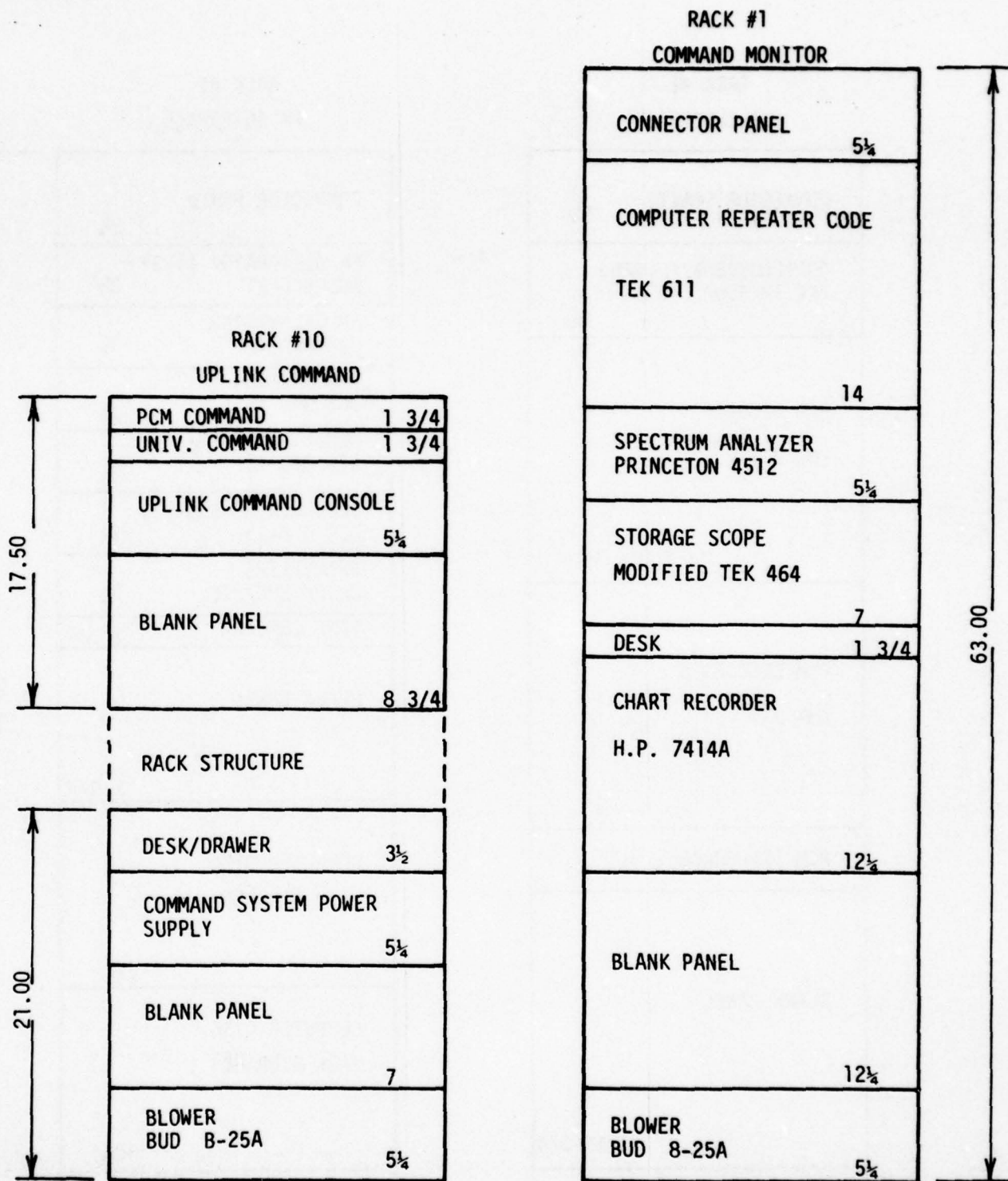


FIGURE 10 RACK NO. 1 AND RACK NO. 10 INSTRUMENTATION CONFIGURATION SHOWING INDIVIDUAL CHASSIS HEIGHTS IN INCHES

RACK #2 PCM INTERFACE	
CONNECTOR PANEL	5¼
OSCILLOSCOPE/F. GEN. TEK TM 500	5¼
PCM DECODER A EMR 711	14
PCM DECODER B EMR 711	14
PCM INTERFACE	3½
BLANK PANEL	15 ¾
BLOWER BUD 8-25A	5¼

RACK #3 FM INTERFACE	
CONNECTOR PANEL	5¼
FM CALIBRATOR (1-21) DCS SCF-21	3½
FM CALIBRATOR USU MOD 1A	3½
DEMODULATOR (1-7) DCS GFD-15	3½
DEMODULATOR (8-14) DCS GFD-15	3½
DEMODULATOR (15-21) DCS GFD-15	3½
AMPLIFIERS DATUM 200/210	3½
TEMP COMMAND	1 ¾
BLANK PANEL	8 ¾
COMPUTER DISC PACK STORAGE	10½
COMPUTER DISC PACK STORAGE	10½
BLOWER BUD 8-25A	5¼

63.00

FIGURE 11 RACK #2 AND #3 INSTRUMENT CONFIGURATION SHOWING INDIVIDUAL CHASSIS HEIGHTS IN INCHES

RACK #4

RADIOMETER MONITOR

CONNECTOR PANEL	5½
RADIOMETER UPLINK COMMAND	3½
OSCILLOSCOPE TEK	5½
BLANK PANEL	5½
CHART RECORDER HP 7414A	10½
BLANK PANEL	21
BLOWER BUD 8-25A	5½

RACK #5

EXPERIMENT UTILITY

CONNECTOR PANEL	5½
INTERCOM FANNON	7
TV MONITOR ELECTROHOME 1110R	10½
DECOM OSU	1 3/4
BLANK PANEL	26½
BLOWER BUD 8-25A	5½

RACK #6

INTERFEROMETER MONITOR

CONNECTOR PANEL	5½
FREQ. COUNTER	3½
OSCILLOSCOPE (INTERFEROMETER)	5½
INTERFEROMETER UPLINK COMMAND	5½
BLANK PANEL	5½
SHELF	1 3/4
TIME CODE GENERATOR	5½
BLANK PANEL	19½
BLOWER BUD 8-25A	5½

56.00

FIGURE 12 RACKS #4, #5, AND #6 INSTRUMENTATION CONFIGURATION SHOWING INDIVIDUAL CHASSIS HEIGHTS IN INCHES

RACK #7
MISSION CONTROL DISPLAYS

BLANK PANEL	3½
2 DUAL OSC./COUNTER TEK SC502 DC 505A	5½
5 MONITOR SCOPED TEK MR501 SC501	5½
4 DIGITAL VOLTMETERS SIMPSON 2850	3½
TIME CODE READER SYS. DON	3½

CONNECTOR PANEL	3½
TV MONITOR	
ELECTROHOME 1410R	12¼
BLANK PANEL	5¼

BLANK PANEL	3½
TEMP MONITORS 4 SIMSON 2850	3½
4 TEMP MONITORS 4 SIMPSON 2850	3½
BLANK PANEL	10½

21.00

FIGURE 13 RACK #7 INSTRUMENTATION CONFIGURATION SHOWING INDIVIDUAL CHASSIS HEIGHTS IN INCHES

RACK #9
OVERHEAD COMMAND CONSOLE

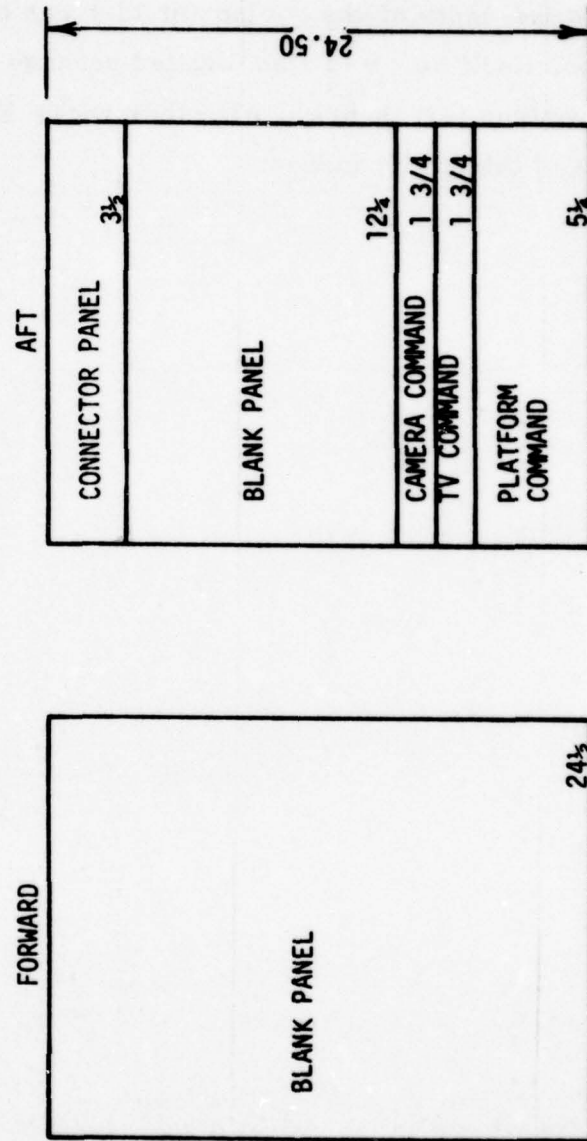


FIGURE 14 RACK #9 INSTRUMENTATION CONFIGURATION SHOWING INDIVIDUAL CHASSIS HEIGHTS IN INCHES

Also indicated are positions in the racks where room is still available for additional equipment - these positions are denoted with "blank panel" labels. It should be pointed out that Racks No. 10 and No. 7 have sloped front panels and thus the depth of the equipment that can be installed is limited. In addition, Rack No. 9 is also limited because the total depth available is only seventeen (17) inches. All other racks have a useable depth (front to back) of thirty (30) inches.

SYSTEM DESCRIPTIONS

General

In this section, the two (2) major interface systems that connect the BAMM Mission Control system with the AFGL telemetry trailer are described. These are the FM telemetry interface and the PCM telemetry interface. In addition, the two major display and data processing systems in Mission Control are also described.

FM Telemetry Interface

FM telemetry data is received, detected, and recorded in the AFGL telemetry trailer. The data is contained in twenty-one (21) standard IRIG frequency modulated channels defined as subcarrier channels and specified in Table 1. The combined signal of all twenty-one (21) channels called a "composite" is fed to Mission Control from AFGL TM over two (2) RG 58 coax cables, see Figure 15. The signal enters Mission Control through the exterior connector panel (insulated feed-through BNC connectors) and is brought into Rack No. 3 through its connector panel slot and is then fed to Dual DC Driver buffer amplifiers. The buffers provide isolation, impedance matching and output level control. Their output feed three (3) banks of discriminators (demodulators) which extract the individual channels from the composite and convert the FM data to analog data signals. The twenty-one (21) output data signals are routed back to the Rack No. 3 connector panel for further distribution to displays, chart recorders, etc. Standard constant amplitude filters (see Table 1 - Nominal Frequency Response) are used in all channels except IRIGS 18, 20 and 21 where wide band (Maximum Frequency Response) linear phase filters are used to accommodate the large bandwidth requirements of the interferometer monochromatic reference and detector data.

PCM Telemetry Interface

The detected PCM data from the AFGL TM receivers is processed in the AFGL trailer through bit synchronizers and is fed to Mission Con-

TABLE 1
PROPORTIONAL SUBCARRIER CHANNELS
 $\pm 7.5\%$ CHANNELS

<u>Channel</u>	<u>Center Frequencies (Hz)</u>	<u>Lower Deviation Limit (Hz)</u>	<u>Upper Deviation Limit (Hz)</u>	<u>Nominal Frequency Response (Hz)</u>	<u>Maximum Frequency Response (Hz)</u>
1	400	370	430	6	30
2	560	518	602	8	42
3	730	675	785	11	55
4	960	888	1,032	14	72
5	1,300	1,202	1,398	20	98
6	1,700	1,572	1,828	25	128
7	2,300	2,127	2,473	35	173
8	3,000	2,775	3,225	45	225
9	3,900	3,607	4,193	59	293
10	5,400	4,995	5,805	81	405
11	7,350	6,799	7,901	110	551
12	10,500	9,712	11,288	160	788
13	14,500	13,412	15,588	220	1,088
14	22,000	20,350	23,650	330	1,650
15	30,000	27,750	32,250	450	2,250
16	40,000	37,000	43,000	600	3,000
17	52,500	48,562	56,438	790	3,938
18	70,000	64,750	75,250	1050	5,250
19	93,000	86,025	99,975	1395	6,975
20	124,000	114,700	133,300	1860	9,300
21	165,000	152,625	177,375	2475	12,375

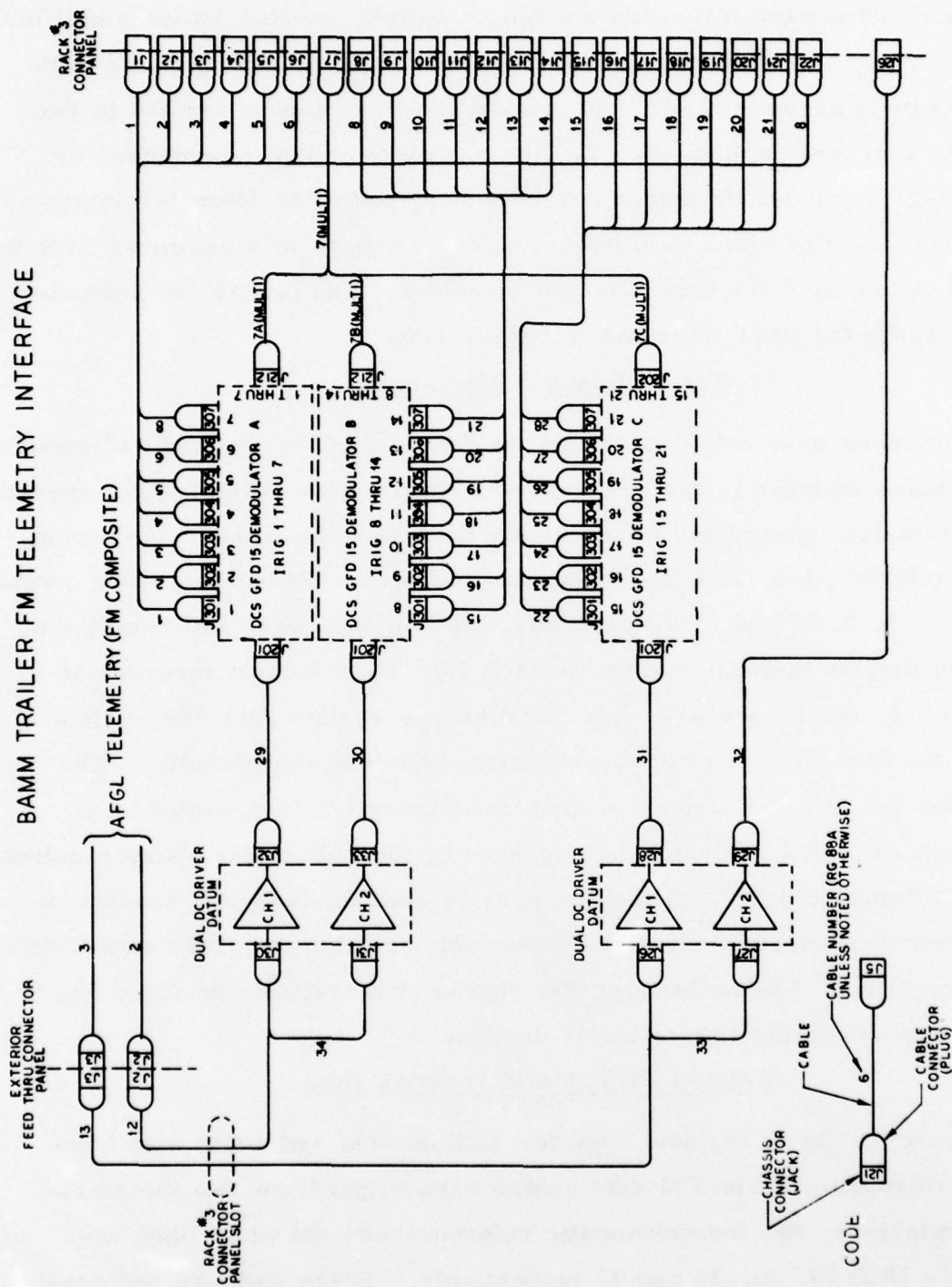


FIGURE 15 BAMM TRAILER FM TELEMETRY INTERFACE

trol over four (4) lines, see Figure 16. The data consist of Link A data, Link A clock, Link B data and Link B clock. These data signals are high frequency coded wave trains and are fed to optical isolator buffer amplifiers in Rack No. 3 where line impedance matching and reshaping of the data wave forms is accomplished. The optical isolator outputs are fed to two (2) PCM decoders in Rack No. 2. The decoders can be commanded by the PDP-11 computer through a specially designed PCM computer interface system part of which is in Rack No. 2. Through this command system desired words from the data base can be selected and sent to the computer again through the PCM interface for processing.

FM Radiometer Monitoring

Continuous monitoring of critical parameters of the payload radiometer performance included in the FM data was required for BAMB flight operations. The parameters prescribed were outputs from two detectors, each having two selectable gains, and the radiometer chopper. These data were contained in IRIG 7, 8, 9, 10 and 13 respectively. These data were fed from Rack No. 3 to display instrumentation in Rack No. 7 and a chart recorder in Rack No. 1, see Figure 17. The oscilloscope system (TM 500 system) display the five (5) data channels simultaneously and continuously. The sweep for the MR-501 display scopes (see Figure 17) is provided by a ramp generator RG 501 which is triggered by the radiometer chopper output. Four (4) Simpson digital voltmeters provide continuous digital readout of the radiometer detector voltages. These data are also recorded on a Z-fold paper recorder. The radiometer FM data is also available at Rack No. 4 for the experimenters to monitor if desired.

FM and PCM Interferometer Data

Figure 18 shows the data flow for both the FM and PCM data from the interferometer. The FM data contains the output from two interferometer detectors, the monochromatic reference and the white light reference - IRIG 19, 20, 21 and 17 respectively. These data are fed from

BAMM TRAILER FM RADIOMETER MONITOR SYSTEM

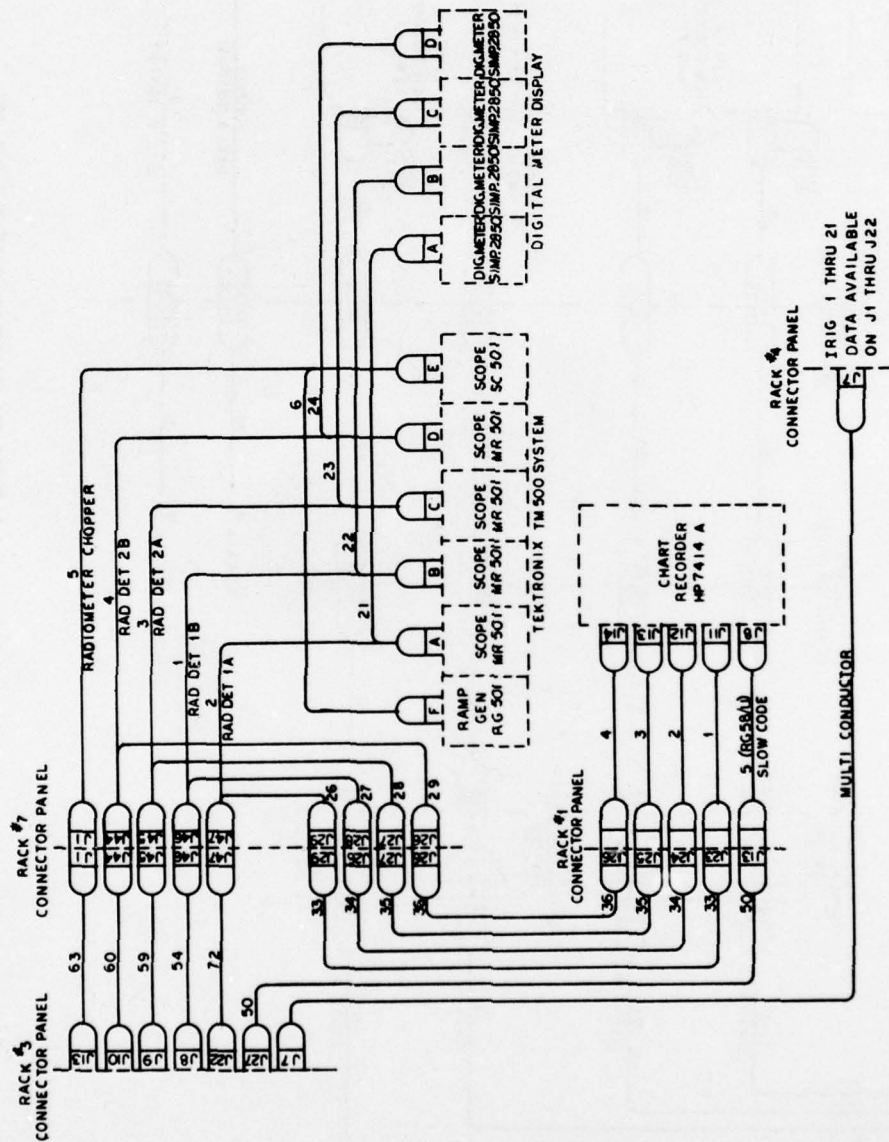


FIGURE 17 FM RADIOMETER OUTPUT DATA DISPLAY SYSTEM

BAMM TRAILER INTERFEROMETER INTERFACE (FM AND PCM)

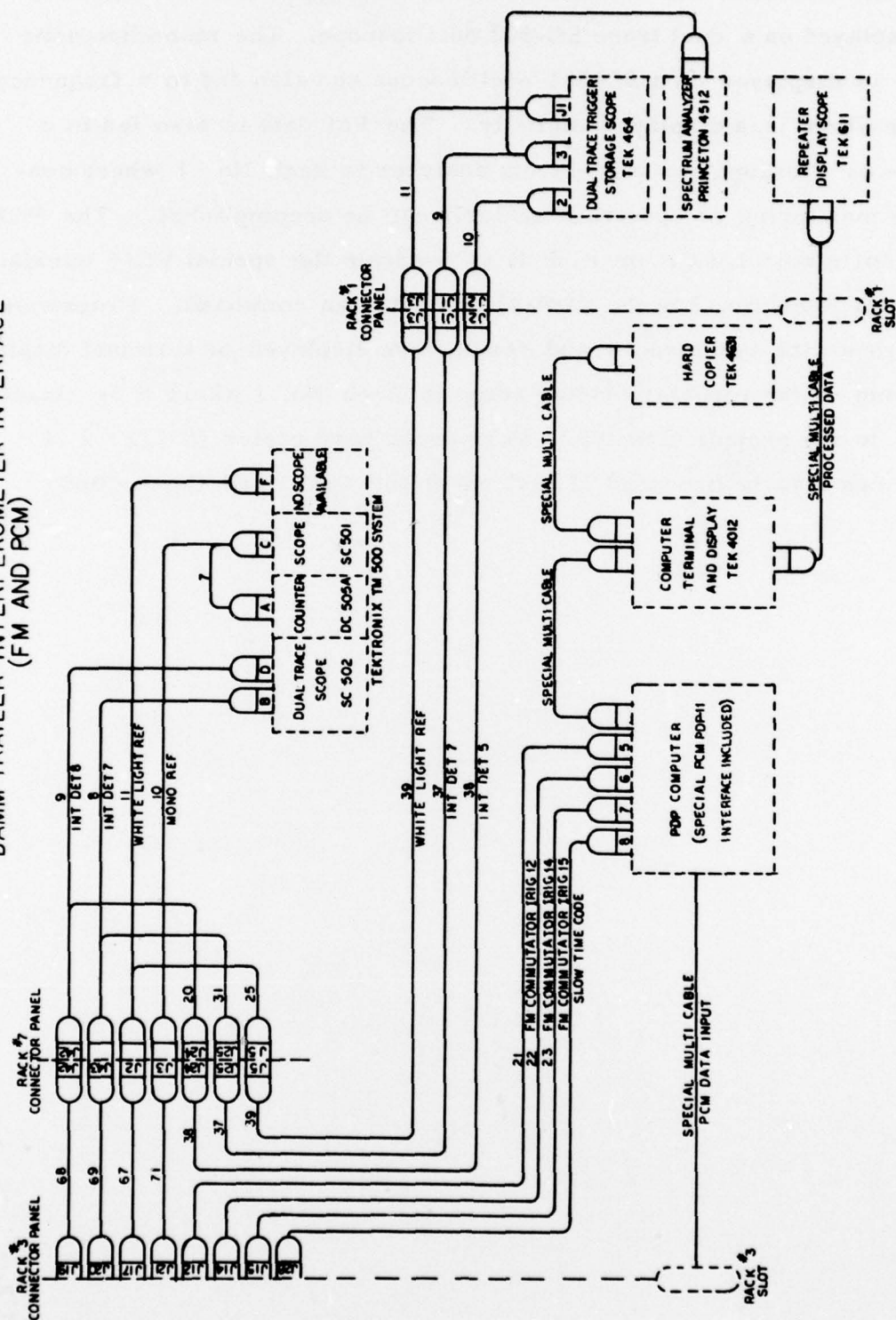


FIGURE 18 FM AND PCM DATA FLOW FOR THE BAMM INTERFEROMETER

Rack No. 3 to Rack No. 7 where the detector outputs (interferograms) are displayed on a dual trace SC-502 oscilloscope. The monochromatic source is displayed on a SC-501 oscilloscope and also fed to a frequency counter where it is displayed digitally. The FM data is also fed to a storage oscilloscope and a spectrum analyzer in Rack No. 1 where continuous monitoring or spectrum analysis can be accomplished. The PCM data from either Link A or Link B is fed from the special PCM interface system in Rack No. 2 to the PDP-11 computer on command. Programmed data processing commences and results are displayed on terminal display scope and on the repeater display scope in Rack No. 1 where it is clearly visible to the project director. Permanent hard copies (8 1/2" x 11" paper) can also be produced if desired on the 4631 Hard Copier Unit.

OTHER SYSTEMS

The BAMM Mission Control facility has other supporting instrumentation systems that are important to mission operations but are less complicated than those described above. Some of these are:

1. Continuous digital meter readout of eight (8) critical payload temperatures (four (4) transmitter temperatures, one (1) battery temperature, two (2) honeycomb temperatures and one (1) payload structure temperature).
2. Continuous Universal Time Code readouts.
3. Two (2) continuous television monitor systems.
4. Tracker parameter readout system.
5. Intercom system.

The uplink command system in Mission Control will be documented by others at a later date.

TEST RESULTS AND RECOMMENDATIONS

Testing of the BAMB Mission Control trailer system was accomplished initially at Visidyne and subsequently in the DC hangar at Hanscom AFB, Massachusetts. Successful testing of all the BAMB Mission Control systems was accomplished, including tests of the FM and PCM interface and display systems, uplink experiment command, computer interface and data processing programs, and the general interface between the AFGL Telemetry/Tracker trailer. Preliminary BAMB Mission Control navigation procedures were developed. Preliminary payload preparedness count-downs were also developed. On a subsequent program, roadworthiness of the trailer and system installation integrity was also established by the fact that the trailer system was transported 6,200 miles over the road from Boston, Massachusetts to Chico, California and returned and suffered no damage.

As a result of these tests and field experience, there are several recommendations for improving the BAMB Mission Control system. These are:

1. Develop a system of data transmitters (line drivers) and receivers to be installed in both the AFGL trailer and the BAMB trailer to replace the current buffer amplifier system. Utilize optical isolator techniques where possible to insure complete signal isolation and line impedance matching.
2. Design and fabricate three (3) decommutators to decode the three (3) thirty (30) segment commutated housekeeping on the FM link. Microprocessor techniques should be considered for this application.
3. Design and fabricate a real time digital readout system to display navigation parameters such as tracker angles and range and pointing platform angles. The latter data

is in the PCM link so PCM work selectors and D to A conversion is required.

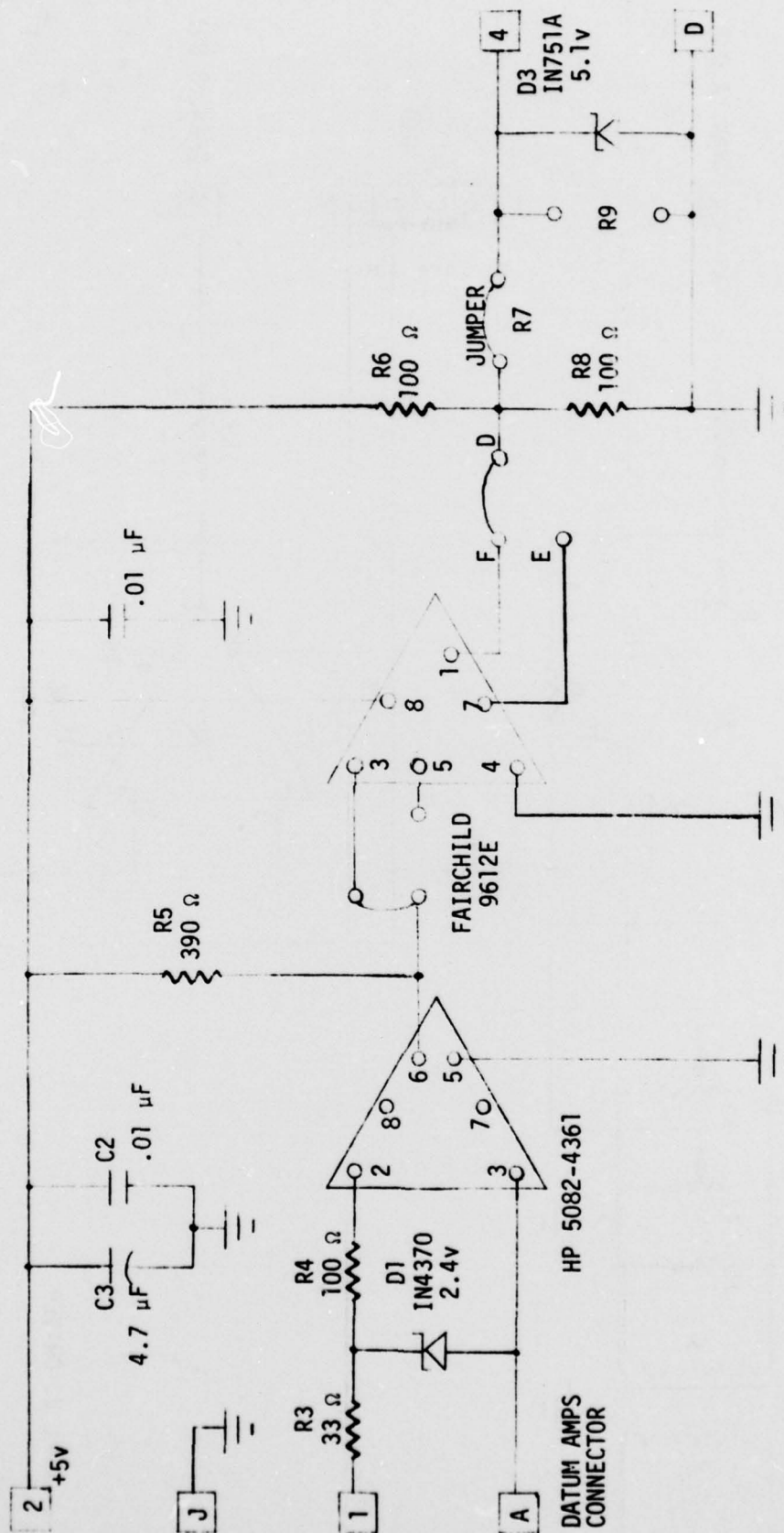
4. Develop computer programs to solve the navigation and target acquisition problem and to display the results.
5. Install an UHF radio system to permit the Field Director to exercise operational command of the BAMB experiment.

ACKNOWLEDGEMENTS

The authors wish to express appreciation to the many scientists, engineers, program directors, and other technical and contractor personnel that contributed to the design and fabrication of the BMM Mission Control facility and preparation of this report. In particular, we wish to gratefully acknowledge the efforts of Drs. R. Murphy and F. Billingsley of AFGL for their overall guidance and encouragement; Messrs. F. Cook and C. Dolan also of AFGL for their expert technical direction and assistance; and Messrs. P. Giordan, R. Rhodes and L. Barnhardt of Fruehauf, Inc. for their efforts in the efficient management of the BMM trailer modification. We also wish to express our thanks to Messrs. G. Aurilio, W. Whelan and W. Sheehan of Visidyne for their help in the design and fabrication of many of the mechanical mounts and subsystems incorporated in the trailer. In addition, appreciation is extended to Ms. B. Cerullo for her superior efforts in the technical typing of this manuscript.

APPENDIX A
ELECTRICAL SCHEMATICS

Figure A1 and A2 are circuit diagrams of the PCM and FM telemetry buffer amplifiers. The PCM buffers are TTL compatible with a bandwidth of about 9 MHz and provide buffering and pulse shaping for the incoming PCM data and clock (each PC board contains two (2) identical amplifiers) before these signals are fed to the PCM decoders. The FM buffers have a bandwidth of 20 HZ to 500 kHz and provide isolation and impedance matching for the incoming FM composite prior to being fed to the FM discriminators. Both units were designed to utilize the Datum Amplifier chassis housing and power supplies.



PCM BUFFER
(BAMM)

NOTE: 2 CK's PER BOARD

FIGURE A1

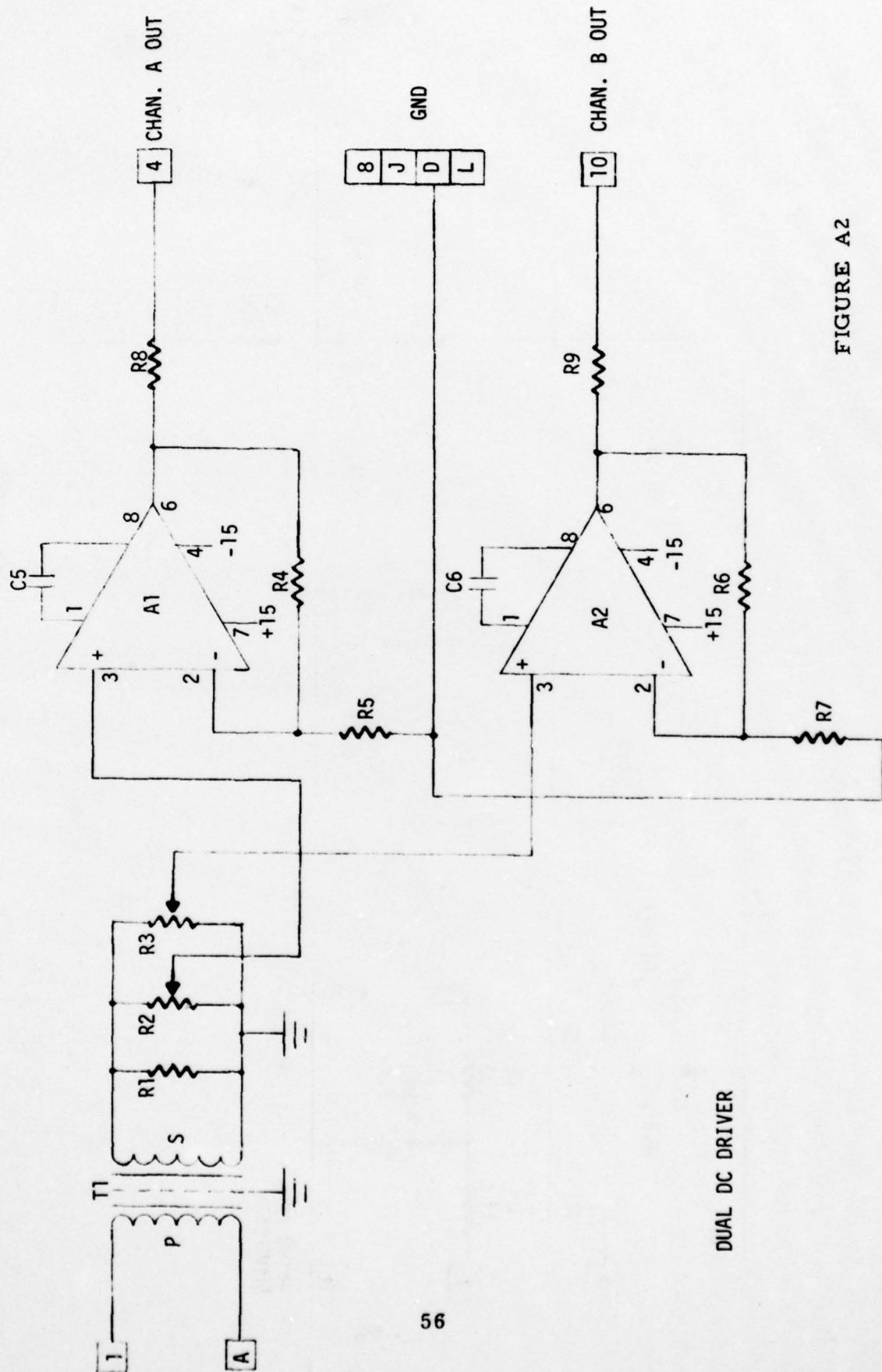


FIGURE A2